ICE THICKNESS IN THE MACKENZIE DELTA:

WINTER 1984-85

D. A. Sherstone
Scientist-in-Charge
Inuvik Scientific Resource Centre

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Inuvik Scientific Resource Centre
Indian and Northern Affairs Canada
P.O. Box 1430
Inuvik, N.W.T. X0E 0T0
Phone (403) 979-3838

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D. A. SHERSTONE

INTRODUCTION

Following ice gauging programs in 1982-83 and 1983-84 a similar program was undertaken for the winter of 1984-85. Unlike the previous winter, favorable weather conditions permitted installation of guages earlier in the year; the first gauges were installed on November 22nd. As a result the record for 1984-85 is the longest of the three winters studied.

The gauges were the same as those used in 1983-84 (Sherstone 1984a, 1984b) and were installed in locations close to those of 1983-84 (Figure 1). When possible these gauges were read at ten day intervals. Readings were taken until gauge removal on May 25th.

Ice thickness values recorded in 1984-85 were generally greater than those of 1982-83 and 1983-84. The exception was East Channel. Because of cold weather during the critical ice formation period (late-September to mid-November) ice growth was rapid prior to the commencement of monitoring. Because of this early thickening of ice the maximum values of ice thickness recorded were the greatest of the three winters studied and also exceeded those recorded in the early 1970's by Anderson and Mackay (1973) and Anderson and Anderson (1974).

INSTALLATION AND MONITORING

Installation of the gauges commenced as soon as the ice was thick enough to support the Resource Centre's four-wheel drive truck (25cm on East Channel). Gauges were installed in locations as close as possible to those of 1983-84. Gauges at East, Bombardier, Napoiak, Aklavik and West Channels were installed at identical sites.

Because of failure of the right bank and partial infilling of the channel at the 1983-84 site, the Oniak Channel gauges were installed approximately 0.5 km further downstream. A large freeze-up jam in Middle Channel caused these gauges to be positioned approximately 1.5 km upstream of the 1983-84 position, in an area of level ice. As a result the transect for the latter site was staggered, with gauges 84-11 and 84-12 placed about 80 metres downstream of 84-09 and 84-10, on the opposite side of the ice road. (Gauge identification numbers are identical to those used in previous winters at the same locations.)

All gauges were installed by January 9th, the date that installation started in 1983-84. Installation technique and equipment was identical to that of the previous winter (Sherstone, 1984b, p.2). The last readings obtained from the ice roads were made on April 29th. Because of delay in obtaining a helicopter the final readings were not made until May 25th when, after a final reading, the gauges were removed.

Gauges were not tied in to transect benchmarks established in 1983-84. While desirable, time and manpower constraints prevented putting extra effort into such additional work. It is planned to survey in the gauges in 1985-86.

RELIABILITY

Of the 20 gauges installed a problem occurred with only one gauge (84-04, Bombardier Channel). This gauge failed soon after installation and was replaced by a new gauge, 85-103, on January 8, 1985. It was not possible to recover gauge 84-04 intact in order to determine the cause of failure but it is suspected that sub-ice debris may have broken the insulated return wire.

All other gauges performed flawlessly throughout the winter.

DISCUSSION OF RESULTS

Maximum thickness values recorded in 1984-85 for each month exceeded those of 1983-84 for all channels except East Channel. In March 1985 ice thickness averaged 35% greater than the corresponding month in 1984. April 1985 values were 20% greater.

May values for the 1984-85 winter exceeded those of 1983-84 for four of the channels (Oniak, Middle, Napoiak and Aklavik). The ice at East Channel and Bombardier Channel was considerably thinner, while West Channel averages were 15cm (11%) greater in 1983-84. These figures are significant because the majority of channels had a greater, retained thickness in May 1985 despite measurement much later in the season (May 25, 1985 compared to May 16, 1984). Thus the 1984-85 ice had an additional nine days of decay before measurement. Throughout this period mean daily air temperatures were within the same range as those of the year before (Figure 2).

The significant thinning of East and Bombardier Channel ice between the last reading of April and that of May is interesting because these sites retained high snow cover throughout the winter and into the initial decay period. This is especially true when compared to channels on the western side of the Delta (see Appendix A). Because of the position of the gauge support frame relative to the ice surface at the time of last reading/removal, it was determined that the predominant melting of the ice cover occurred at the lower, ice-water interface and not at the upper, air-ice boundary. In 1983-84 most of the gauges had to be chopped free of the frozen slush used to fix the gauges during installation. In 1984-85 surface melting had freed most of the gauges prior to removal. Thus the input of heat to the ice from below; from water flowing northward from warmer, upstream areas of the basin, is the main contributor to reduction in the ice cover prior to break-up.

No reason for the relatively greater thinning of East Channel and Bombardier Channel ice is known at this time. East Channel at Inuvik carries only seven to nine percent of the total flow in the Mackenzie Delta thus is not the major initiator of Delta break-up. Meltwater from

east side (and generally south-facing) tributary basins enters this channel at the time of ice decay, but within the Delta proper the volume of water introduced is not large. Effluent from the sewage lagoon at Inuvik may be a contributing factor, although the magnitude of heat input from this source is unknown. (Because of heavy, unregulated water use in Inuvik and freezing to the bed of the tertiary lagoon cell catastrophic overflows from the lagoon flooded East Channel and the interconnecting lakes several times in the late-Winter, early-Spring period.) To determine the importance of heat input from these sources extensive temperature monitoring of East Channel would be required.

Maximum ice thickness' were reached in late April in 1984-85 (Figure 3). Individual gauge maxima occurred at the end of April, which accords well with the date maxima were achieved in 1983-84 (Table 1).

Two channels were partially blocked by freezing of channel ice to the bed. Gauges 84-05 (Oniak Channel) and 84-03 (Bombardier Channel) froze to the bed by early March, thus constricting flow. The depth to the bed at the time of gauge installation was 157cm at gauge 84-05 and 108cm at gauge 84-03. Despite the depth to bed being only 111cm at gauge 84-04 (85-103), also located on Bombardier Channel, flow continued beneath this gauge throughout the winter. Maximum recorded ice values at 84-04 reached 114.5cm (of which 4.5cm was overflow, white ice). This suggests that localized scour of the bed in the area of the gauges took place in order to permit continued discharge.

Again in 1984-85 no evidence of frazil ice was observed during the period of record. This agrees with previous experience in this study and with earlier work in the same areas (Anderson and Mackay, 1973).

REFERENCES

Anderson, J.C. and Anderson, R.J. (1974). "Progress Report on Winter Distribution of Flow in the Mackenzie Delta, N.W.T." Hydrologic Aspects of Northern Pipeline Development, 1974, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development, Report 74-12, Ottawa, pp. 225-254.

Anderson, R.J. and Mackay, D.K. (1973). "Seasonal Distribution of Flow in the Mackenzie Delta, N.W.T." Hydrologic Aspects of Northern Pipeline Development, Environmental-Social Committee, Northern Pipelines, Task Force on Northern Oil Development, Report No. 73-3, Ottawa, pp. 71-110.

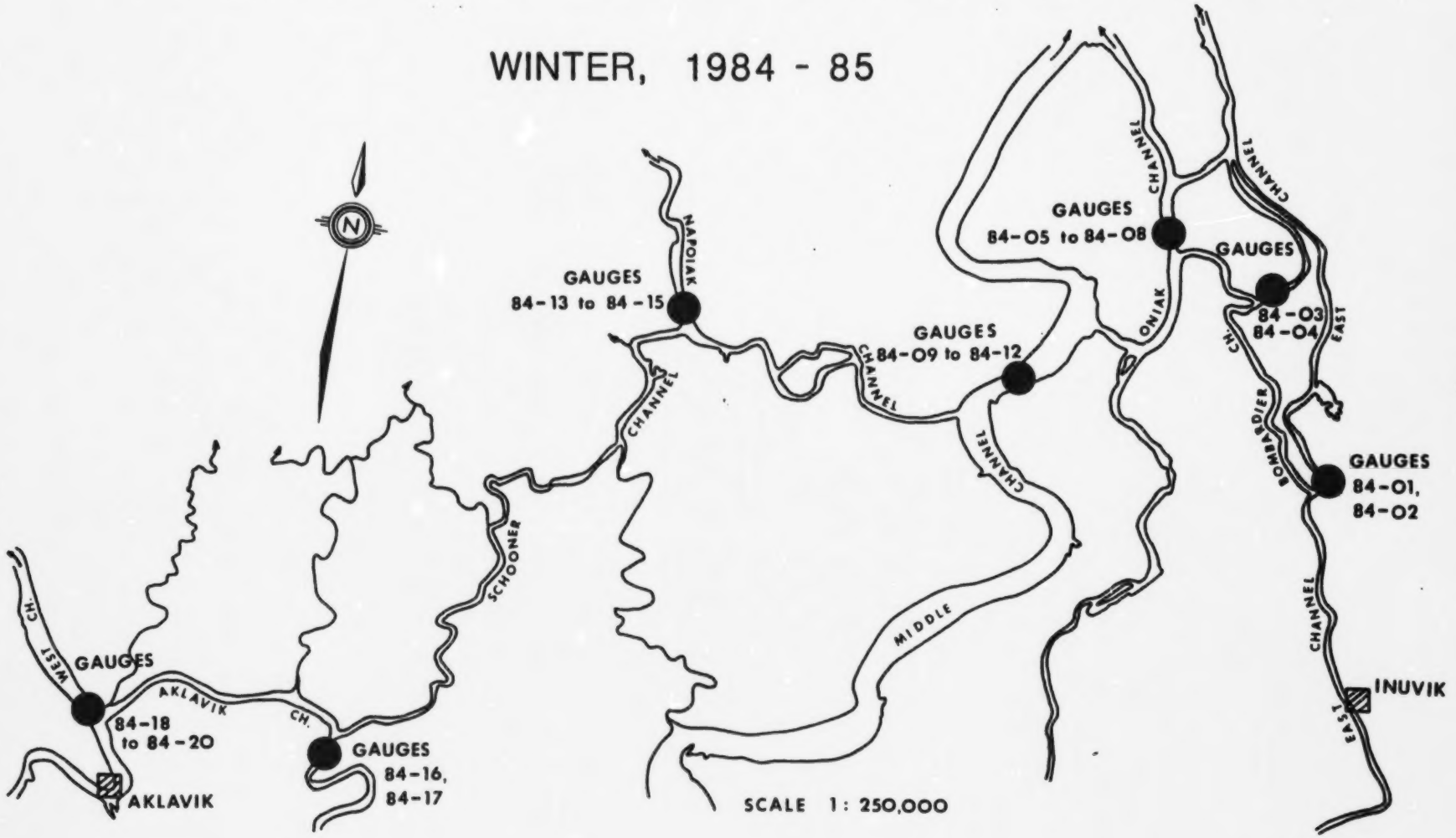
Sherstone, D.A. (1984a). Ice Thickness In the Mackenzie Delta: Winter 1982-83: Data Obtained from Hot-Wire Gauge System. Report 84-1, Inuvik Scientific Resource Centre, Dept. of Indian Affairs and Northern Development, Inuvik, Feb., 16 p.

Sherstone, D.A. (1984b). Ice Thickness in the Mackenzie Delta: Winter 1983-84: Data Obtained from Hot-Wire Gauges. Report 84-4, Inuvik Scientific Resource Centre, Dept. of Indian Affairs and Northern Development, Inuvik, Oct., 16 p.

FIGURE 1

LOCATION OF ICE GAUGES, MACKENZIE DELTA, N.W.T.

WINTER, 1984 - 85



MEAN DAILY AIR TEMPERATURES (DEG. C)

INUVIK AIRPORT: WINTERS 1982-83 TO 1984-85

FIVE DAY RUNNING MEAN

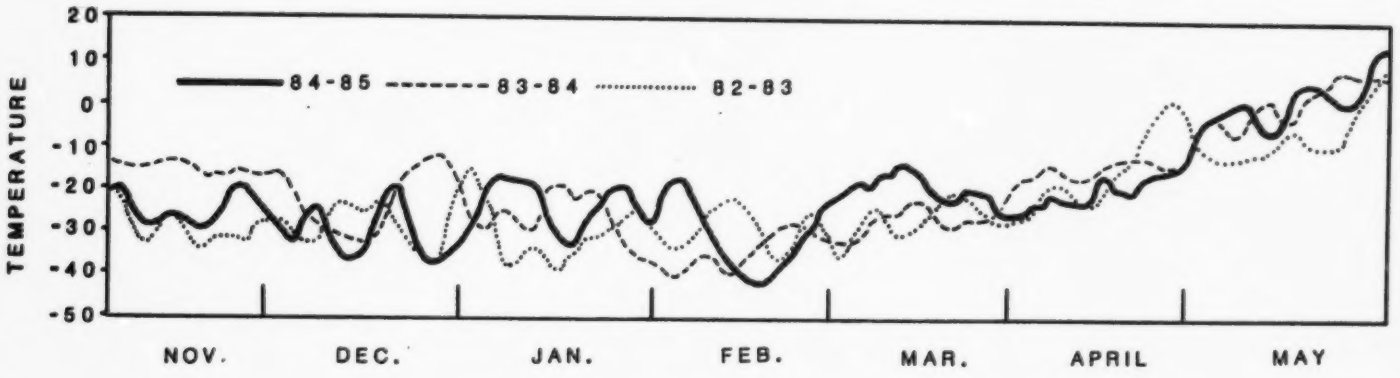


FIGURE 2

Table 1

Maximum Single Ice Thickness

Recorded at Each River Channel

Winters 1982-83, 1983-84, 1984-85

		Thickness	Gauge	Date
East Channel	82-83	98.0cm	82-14	April 12
	83-84	105.0	84-02	April 27 & May 3
	84-85	95.5	84-02	April 29
Bombardier	82-83	n.a.		
	83-84	113.0	84-03	April 27
	84-85	111.0	85-103	April 29
Oniak	82-83	n.a.		
	83-84	114.0	84-05	May 3
	84-85	163.0	84-07	April 29
Middle	82-83	117.0	82-07	April 12
	83-84	129.5	84-11	May 3
	84-85	153.5	84-10	April 29
Napoiak	82-83	n.a.		
	83-84	148.5	84-15	May 3
	84-85	158.0	84-13	April 29
Aklavik	82-83	n.a.		
	83-84	120.5	84-17	May 3
	84-85	148.0	84-17	April 29
West	82-83	n.a.		
	83-84	150.0	84-20	May 3
	84-85	174.0	84-19	April 29

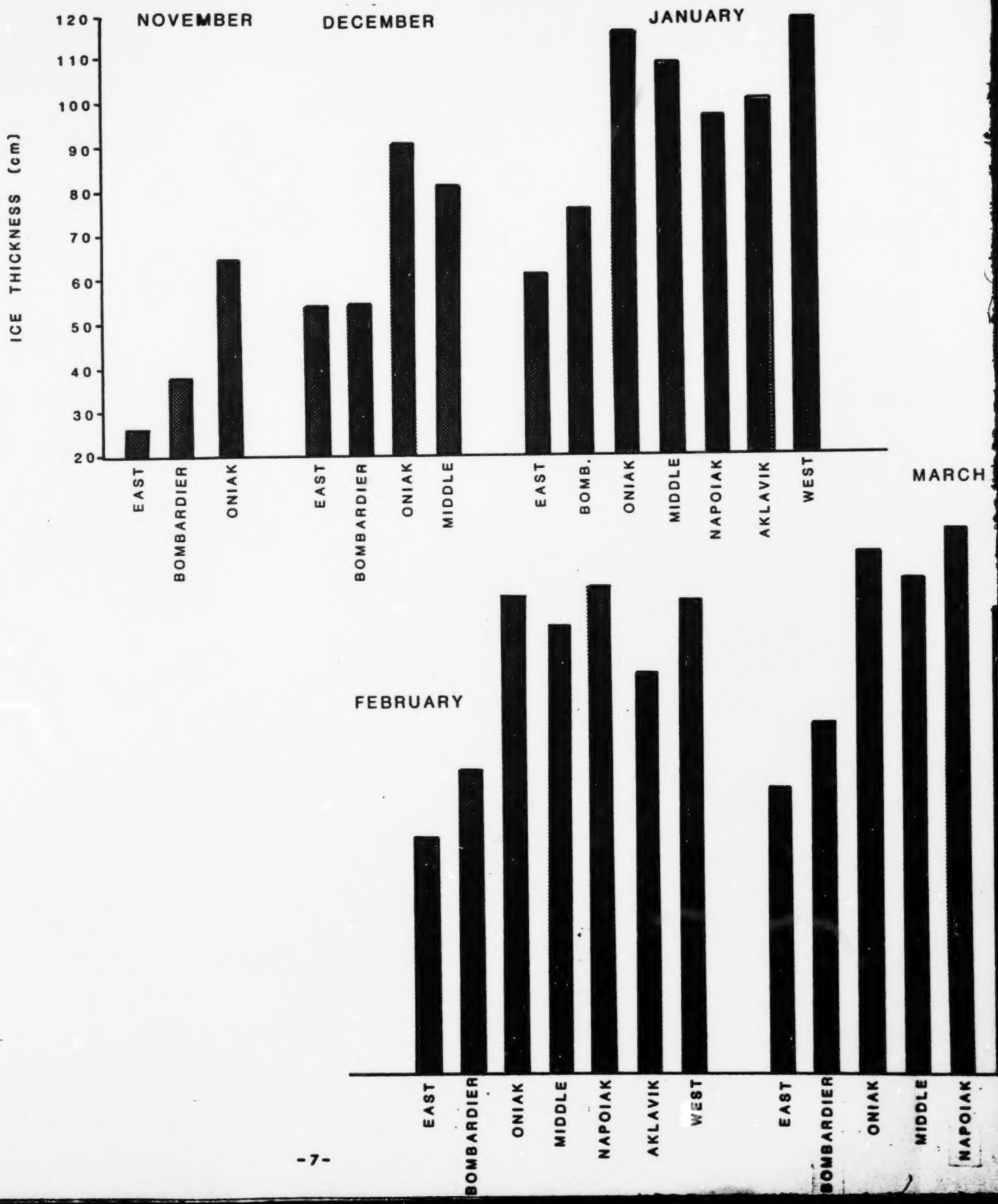
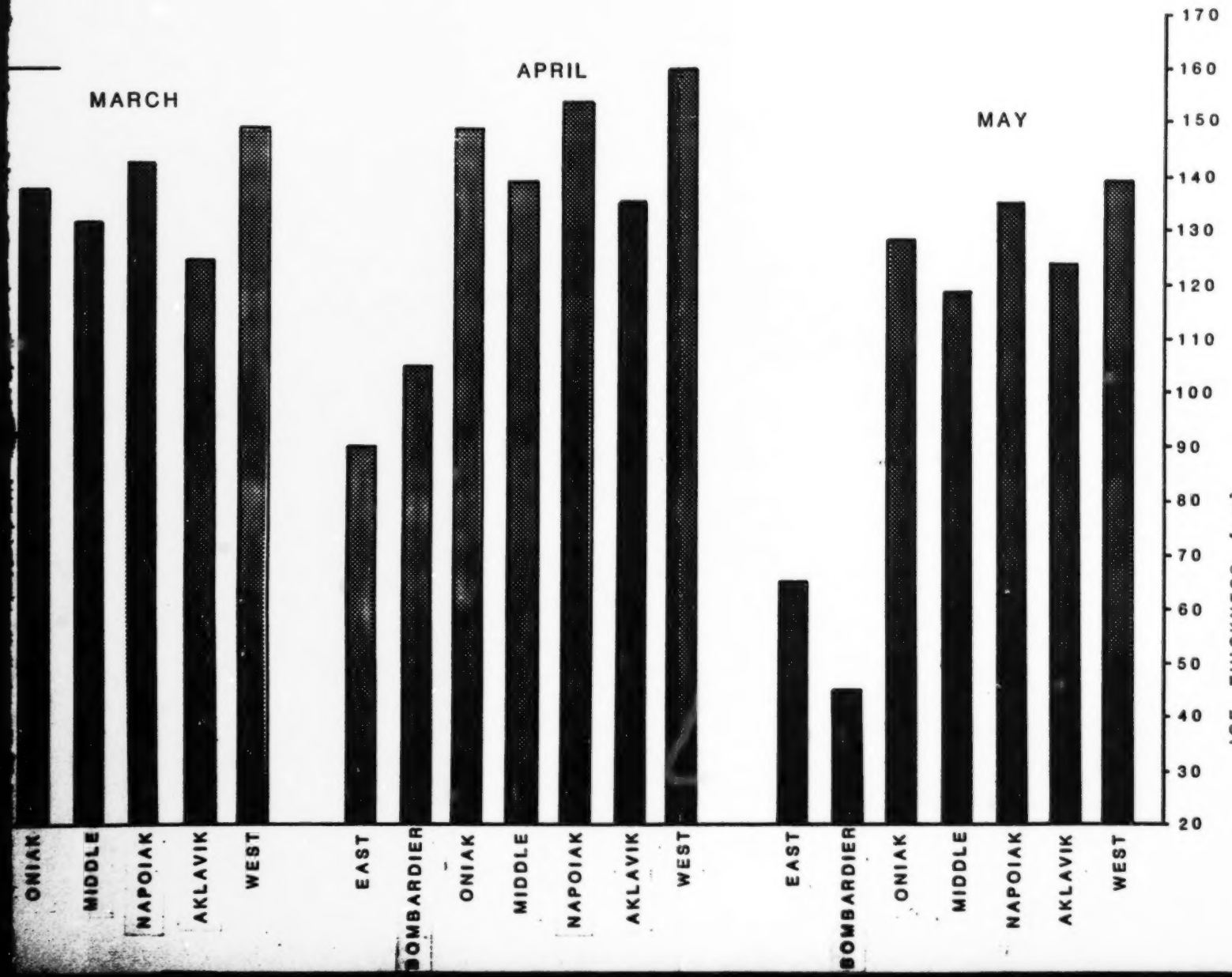

ICE THICKNESS (cm)
120
110
100
90
80
70
60
50
40
30
20
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
EAST
BOMBARDIER
ONIAK
EAST
BOMBARDIER
ONIAK
MIDDLE
EAST
BOMB.
ONIAK
MIDDLE
NAPOIAK
AKLAVIK
WEST
EAST
BOMBARDIER
ONIAK
MIDDLE
NAPOIAK
AKLAVIK
WEST
EAST
BOMBARDIER
ONIAK
MIDDLE
NAPOIAK

FIGURE 3

MEAN MONTHLY ICE THICKNESS

FOR EACH RIVER CHANNEL MONITORED

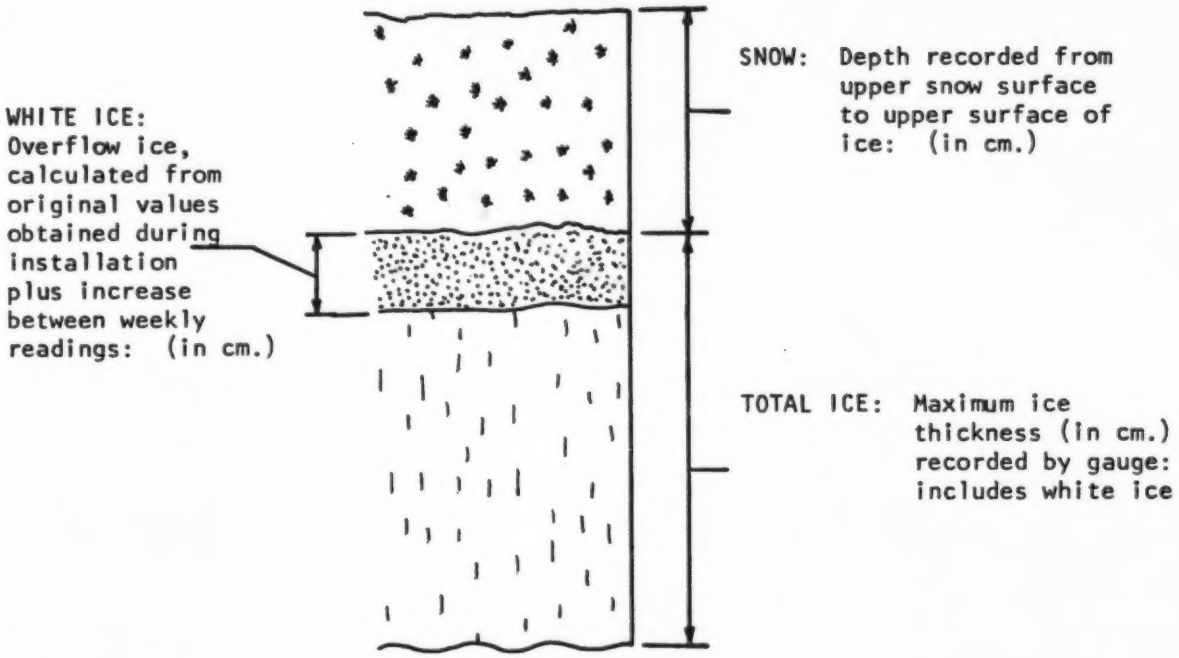
WINTER 1984 - 85



APPENDIX A:

RECORDED DATA FROM ICE GAUGES:

WINTER 1984-85


WHITE ICE:
Overflow ice, calculated from original values obtained during installation plus increase between weekly readings: (in cm.)
SNOW: Depth recorded from upper snow surface to upper surface of ice: (in cm.)
TOTAL ICE: Maximum ice thickness (in cm.) recorded by gauge: includes white ice

GAUGE DATA - MACKENZIE DELTA - 84-85

GAUGE 84-01

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 22	28(cm)	NIL	11(cm)
Dec 8	47	NIL	15.0
Dec 28	68.5	NIL	16.0
Jan 16	57.0	NIL	23.0
Jan 24	62.0	NIL	24.0
Feb 6	67.5	NIL	34.0
Feb 22	71.5	NIL	33.0
Mar 6	78.0	NIL	34.0
Mar 15	83.5	NIL	35.0
Mar 25	88.0	NIL	35.0
Apr 9	87.0	NIL	41.0
Apr 18	84.0	NIL	43.0
Apr 29	82.5	NIL	39.0
May 25	56.5	4.0	NIL

GAUGE 84-02

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 22	25(cm)	NIL	12(cm)
Dec 8	47.0	NIL	14.0
Dec 28	52.5	NIL	12.0
Jan 8	53.0	N.A.	N.A.
Jan 16	84.0	NIL	21.0
Jan 24	70.0	NIL	12.0
Feb 6	75.5	NIL	30.0
Feb 22	80.5	NIL	33.0
Mar 6	83.5	NIL	30.0
Mar 15	86.5	NIL	31.0
Mar 25	91.5	NIL	29.0
Apr 9	94.5	NIL	37.0
Apr 18	93.5	NIL	40.0
Apr 29	95.5	NIL	37.0
May 25	73.0	NIL	NIL

GAUGE 84-03

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 22	39(cm)	NIL	8(cm)
Dec 8	50.0	NIL	11.0
Dec 28	68.0	NIL	14.0
Jan 16	74.5	NIL	19.0
Jan 24	79.5	NIL	20.0
Feb 6	84.0	NIL	32.0
Feb 22	93.5	NIL	31.0
Mar 6	94.5	NIL	30.0
Mar 15	FROZEN TO BED		35.0
Mar 25	FROZEN TO BED		
Apr 9	FROZEN TO BED		36.0
Apr 18	FROZEN TO BED		38.0
Apr 29	FROZEN TO BED		
May 25	55.0	5.0	NIL

GAUGE 84-04 (85-103)

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 22	38(cm)	NIL	9(cm)
Dec 8	52.5	NIL	13.0
Dec 28	GAUGE BROKEN		11.0
Jan 16	71.5	NIL	N.A.
Jan 24	80.0	NIL	15.0
Feb 6	87.5	NIL	28.0
Feb 22	94.5	NIL	28.0
Mar 6	102.0	4.0	23.0
Mar 15	104.5	4.5	22.0
Mar 25	107.5	4.5	22.0
Apr 9	113.0	4.5	37.0
Apr 18	114.5	4.5	38.0
Apr 29	111.0	4.5	32.0
May 25	34.0	NIL	NIL

GAUGE 84-05

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 26	74(cm)	NIL	NIL
Dec 8	91.5	NIL	6.0
Dec 28	119.5	NIL	4.0
Jan 16	130.0	NIL	15.0
Jan 24	135.0	NIL	14.0
Feb 6	142.0	NIL	22.0
Feb 22	146 Frozen to bottom	NIL	22.0
Mar 6	FROZEN TO BED		
Mar 15	FROZEN TO BED		
Mar 25	FROZEN TO BED		
Apr 9	FROZEN TO BED		
Apr 18	FROZEN TO BED		
Apr 29	FROZEN TO BED		
May 25	129.0	NIL	NIL

GAUGE 84-06

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 26	61(cm)	NIL	2 (cm)
Dec 8	78.0	NIL	10.0
Dec 28	104.5	NIL	10.0
Jan 16	113.5	NIL	13.0
Jan 24	119.5	NIL	11.0
Feb 6	127.5	NIL	20.0
Feb 22	134.0	NIL	22.0
Mar 6	141.5	NIL	28.0
Mar 15	143.5	NIL	32.0
Mar 25	147.0	NIL	30.0
Apr 9	151.5	NIL	39.0
Apr 18	156.0	NIL	40.0
Apr 29	155.5	NIL	35.0
May 25	120.0	NIL	NIL

GAUGE 84-07

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 26	75(cm)	NIL	7(cm)
Dec 8	88.0	NIL	10.0
Dec 28	110.5	NIL	12.0
Jan 10	119.5	NIL	18.0
Jan 16	120.0	NIL	18.0
Jan 24	125.5	NIL	19.0
Feb 6	131.0	NIL	30.0
Feb 22	139.0	NIL	30.0
Mar 6	144.5	NIL	23.0
Mar 15	147.0	NIL	28.0
Mar 25	150.5	NIL	28.0
Apr 9	155.5	NIL	40.0
Apr 18	158.5	NIL	42.0
Apr 29	163.0	NIL	30.0
May 25	141.0	NIL	NIL

GAUGE 84-08

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 26	51(cm)	NIL	13(cm)
Dec 8	61.0	NIL	13.0
Dec 28	85.5	NIL	15.0
Jan 10	92.0	NIL	17.0
Jan 16	93.5	NIL	19.0
Jan 24	102.5	NIL	18.0
Feb 6	106.0	NIL	32.0
Feb 22	111.0	NIL	33.0
Mar 6	119.0	NIL	26.0
Mar 15	121.5	NIL	28.0
Mar 25	125.5	NIL	26.0
Apr 9	131.5	NIL	32.0
Apr 18	134.5	NIL	36.0
Apr 29	135.0	NIL	32.0
May 25	123.0	NIL	NIL

GAUGE 84-09

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	83(cm)	NIL	3(cm)
Dec 28	109.0	NIL	6.0
Jan 16	118.5	NIL	11.0
Jan 24	122.5	NIL	10.0
Feb 6	128.5	NIL	15.0
Feb 22	135.5	NIL	22.0
Mar 6	140.0	NIL	26.0
Mar 15	141.0	NIL	20.0
Mar 26	143.0	NIL	21.0
Apr 9	148.0	NIL	32.0
Apr 18	150.5	NIL	32.0
Apr 29	152.0	NIL	25.0
May 25	132.0	NIL	NIL

GAUGE 84-10

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	84(cm)	NIL	2(cm)
Dec 28	106.5	NIL	9.0
Jan 16	118.5	NIL	12.0
Jan 24	123.0	NIL	12.0
Feb 6	136.0	NIL	21.0
Feb 22	133.0	NIL	21.0
Mar 6	138.5	NIL	18.0
Mar 15	141.0	NIL	19.0
Mar 26	145.5	NIL	18.0
Apr 9	150.5	NIL	23.0
Apr 18	152.5	NIL	29.0
Apr 29	153.0	NIL	19.0
May 25	NOT READABLE - HOLE OPEN		

GAUGE 84-11

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	78(cm)	NIL	2(cm)
Dec 28	102.5	NIL	13.0
Jan 10	111.0	NIL	14.0
Jan 16	112.5	NIL	22.0
Jan 24	118.0	NIL	13.0
Feb 6	124.5	NIL	25.0
Feb 22	132.0	NIL	23.0
Mar 6	137.0	NIL	16.0
Mar 15	139.0	NIL	20.0
Mar 26	141.5	NIL	20.0
Apr 9	147.0	NIL	30.0
Apr 18	149.0	NIL	31.0
Apr 29	151.5	NIL	21.0
May 25	126.5	NIL	NIL

GAUGE 84-12

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	50(cm)	NIL	14(cm)
Dec 28	69.0	NIL	6.0
Jan 16	77.5	NIL	15.0
Jan 24	81.0	NIL	13.0
Feb 6	87.5	NIL	42.0
Feb 22	92.0	NIL	41.0
Mar 6	97.0	NIL	85.0
Mar 15	97.5	NIL	84.0
Mar 26	101.5	NIL	81.0
Apr 9	104.5	NIL	91.0
Apr 18	106.0	NIL	91.0
Apr 29	114.5	NIL	98.0
May 25	97.0	NIL	39.0

GAUGE 84-13

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 8	111(cm)	NIL	8(cm)
Jan 24	119.0	NIL	6.0
Feb 6	125.0	NIL	16.0
Feb 22	131.0	NIL	18.0
Mar 6	139.0	NIL	9.0
Mar 15	142.0	NIL	11.0
Mar 26	146.0	NIL	11.0
Apr 9	152.0	NIL	20.0
Apr 18	155.0	NIL	23.0
Apr 29	158.0	NIL	10.0
May 25	131.5	4.0	NIL

GAUGE 84-14

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 8	118(cm)	NIL	8(cm)
Jan 24	120.5	NIL	9.0
Feb 6	127.5	NIL	20.0
Feb 22	133.5	NIL	20.0
Mar 6	138.5	NIL	12.0
Mar 15	142.0	NIL	15.0
Mar 26	147.5	NIL	14.0
Apr 9	152.5	NIL	25.0
Apr 18	156.5	NIL	25.0
Apr 29	155.5	NIL	19.0
May 25	135.0	4.5	NIL

GAUGE 84-15

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 8	117(cm)	NIL	10(cm)
Jan 24	122.0	NIL	4.0
Feb 6	129.0	NIL	19.0
Feb 22	134.5	NIL	21.0
Mar 6	139.5	NIL	36.0
Mar 15	142.0	NIL	35.0
Mar 26	144.0	NIL	35.0
Apr 9	148.0	NIL	44.0
Apr 18	151.0	NIL	44.0
Apr 29	153.0	NIL	33.0
May 25	136.5	1.5	NIL

GAUGE 84-16

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 9	92(cm)	NIL	22(cm)
Jan 24	90.0	NIL	25.0
Feb 6	95.0	NIL	35.0
Feb 22	102.0	NIL	33.0
Mar 6	108.0	NIL	29.0
Mar 15	111.0	NIL	31.0
Mar 26	115.0	NIL	35.0
Apr 9	120.5	NIL	31.0
Apr 18	123.5	NIL	33.0
Apr 29	127.5	NIL	25.0
May 25	GAUGE PULLED THRU SLUSH		NIL

GAUGE 84-17

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 9	108(cm)	NIL	12(cm)
Jan 24	113.5	NIL	15.0
Feb 6	120.0	NIL	25.0
Feb 22	126.5	NIL	24.0
Mar 6	133.0	NIL	20.0
Mar 15	135.5	NIL	20.0
Mar 26	139.5	1.0(cm)	20.0
Apr 9	144.5	1.0	38.0
Apr 18	147.0	1.0	38.0
Apr 29	148.0	1.0	27.0
May 25	123.0	NIL	NIL

GAUGE 84-18

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 9	111(cm)	NIL	16(cm)
Jan 24	113.5	NIL	19.0
Feb 6	117.5	NIL	24.0
Feb 22	127.5	NIL	26.0
Mar 6	135.0	NIL	17.0
Mar 15	141.0	NIL	20.0
Mar 26	144.0	NIL	20.0
Apr 9	149.5	NIL	21.0
Apr 18	154.0	NIL	29.0
Apr 29	156.5	NIL	20.0
May 25	136.0	NIL	NIL

GAUGE 84-19

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 9	125(cm)	NIL	9(cm)
Jan 24	128.0	NIL	10.0
Feb 6	134.5	NIL	10.0
Feb 22	144.5	NIL	10.0
Mar 6	152.5	NIL	9.0
Mar 15	156.5	NIL	12.0
Mar 26	161.0	NIL	10.0
Apr 9	168.0	NIL	25.0
Apr 18	171.0	NIL	24.0
Apr 29	174.0	NIL	15.0
May 25	139.5	NIL	NIL

GAUGE 84-20

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 9	115(cm)	NIL	17(cm)
Jan 24	117.0	NIL	18.0
Feb 6	115.0	NIL	25.0
Feb 22	132.5	NIL	26.0
Mar 6	139.5	NIL	39.0
Mar 15	142.5	NIL	38.0
Mar 26	146.0	NIL	37.0
Apr 9	152.0	NIL	43.0
Apr 18	154.0	NIL	38.0
Apr 29	158.0	NIL	35.0
May 25	144.0	NIL	NIL